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DOUBLE SEALED ALKALINE STORAGE CELL

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DOUBLE SEALED ALKALINE STORAGE CELL

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Brief Description of Figures

Fig. 1 is a partial cutaway schematic side view of an example of a sealed cell made by this invention; Fig. 1-A and Fig. 1-B are variations of the gas vent system of the sealed cell shown in Fig. 1, and Fig. 2 is a top view of the cell shown in Fig. 1.

Detailed Description of Invention

This invention deals with a rechargeable sealed cell which functions with alkaline electrolyte and produces excessive internal gas pressure during charging. It refers to a nickel-cadmium cell of this type, although the invention is useful in its details in a wide range for other types of rechargeable cells. The practical example of this invention described in the following concerns a sealed nickel-cadmium battery.

As a method to prevent the cell container from damage bursting due to excessive internal pressure of evolving gas, the nickel-cadmium cell is sealed with a thin, flexible membrane which can be punctured

or broken by a projection or sharp pin on the cell container when a certain excessive internal pressure is reached. Once the thin membrane 1 [sic] of the sealed cell is broken by internal gas pressure, a part of the vapor or gas which is produced by some of the electrolyte in the cell in each following charging process, is vented into the outer space through the broken part of the membrane. Such an increased loss of electrolyte due to the following charging process or storage of the cell gradually reduces the charging capacity of the cell until it has to be replaced by a new one and wasted.

One of the objectives of this invention is the above-cited sealed rechargeable cell which can restrict the loss of electrolyte after the protective membrane is broken by excessive internal pressure. According to the invention, the part of the cell container which faces outside of the cell, and on which the breakable membrane is installed, is constructed in such a way that a gas vent hole which is positively sealed against gas or vapor leakage and prevents the gas from leaking out through the broken part of the membrane.

This invention was developed for sealed rechargeable nickel-cadmium cells and is particularly useful for these, although it can be applied to other kinds of sealed rechargeable cells. Hence the principle of this invention is described with reference to the nickel-cadmium cell. Almost all rechargeable sealed nickel-cadmium batteries consist of electrode grids made of sintered nickel powder, each of the holes of the grids being filled with active material. However, this kind of battery can be operated with the pocket type electrodes described in the U.S. Pat. No. 3,022,363 by P. S. Gleager. In all rechargeable nickel-cadmium cells, the cathode material consists of bivalent nickel hydroxide with two valencies, $Ni(OH)_2$, which is converted to trivalent nickel hydroxide, i.e. highly oxidized nickel, $Ni(OH)$, when the cathode is completely charged. The discharged anode of this kind of cell consists of bivalent cadmium hydroxide, $Cd(OH)_2$, which is converted to metallic cadmium when the anode is completely charged.

As explained in U.S. Pat. No. 2,131,592 by Runge, and in British Pat. No. 3,171,30 (1929) by Pui and Harold, the anode capacity of the nickel-cadmium cell has to be made higher than that of the cathode so that all of the oxygen formed during charging will be absorbed by

the anode. This invention is useful not only for the sealed nickel-cadmium storage cell which is operated by an electrode assembly in which the grid holes are not sufficiently filled with electrolyte, but also for the sealed cell made by this invention consisting of an electrode assembly in which every hole and space are filled and saturated with electrolyte and which is welded to the wall of the surrounding cell container or is fitted into the container.

The quality of the sealed rechargeable nickel-cadmium cell is determined by the power to maintain a constant charge-discharge characteristic with repeated charging and with a large number of charge-discharge cycles in its long effective shelf life. Some of the cells which were checked by standard quality control in the manufacture of sealed nickel-cadmium cells, will evolve excessive internal pressure during charging. This excessive internal pressure produced in the sealed cell will cause swelling of the cell container made of strong metal, and then cause dangerous bursting of the cell container.

In order to solve this problem, a breakable, thin metal membrane was installed on this kind of sealed type cell in the prior art. But, once the breakable, thin membrane on the sealed cell is broken, some parts of electrolyte in the cell are converted to gas or vapor during the charging process, a part of which leaks through the broken membrane. Consequently, the cell with the broken membrane continues to lose electrolyte during the cell charging process and by vaporization. The loss of electrolyte reduces the charging capacity of the cell until the cell becomes inactive or its capacity drops, even though the electrode assembly functions sufficiently for a long time except for lack of electrolyte.

According to this invention, in the zone of the container of a sealed nickel-cadmium cell facing the outer surface of the membrane which can be punctured or broken, a gas vent hole is installed, which is closed under normal conditions to keep the internal cell parts sealed, and which prevents electrolyte vapor or gas from leaking even when the thin breakable membrane is broken by excessive internal pressure. The gas vent hole which is closed under normal conditions is installed in such a way that its valve mechanism is opened to allow gas to leak out of the cell only when the internal gas pressure reaches such a high level that the cell container swells and would be broken by the pressure.

A practical version of a rechargeable sealed storage cell designed according to this invention is shown in Figs. 1 and 2. The cell consists of an electrode assembly of one or more pairs of stacked cathode plates (+) 14 and anode plates (-) 15 with a porous insulating separator 16. The electrode assembly has pores which contain and retain alkaline electrolyte. The cell shown in the figure consists of only one pair of stacked electrode plates 14(+) and 15(-) with separator 16 in between, covered with electrode assembly 13 which is fitted and fixed to cylindrical container 21. The cylindrical container 21 consists of bottom plate 22 and upper opening surrounded by the nearly cylindrical container closure 23. In the upper container closure 23, the rim 32 of metal cover 31 is held in the non-conducting packing 24.

The non-conductive packing 24 is composed of a relatively thick ring 24 made of non-conducting, gas-impermeable nylon. The ring is pressed and held against the edge and the two surfaces of the cover rim 32 by the container closure 23 surrounding the lid rim 32. Inside the container the container closure 23 has shoulder 25 and edge 26 outside of the container and they press on both sides of the non-conducting ring and consequently both surfaces of the cover rim 32, so that this part is sealed air-tight and insulated.

The container 21 and cover 31 are formed of strong, gas-impermeable metal, such as gas-impermeable, milled steel material coated with thin alkali-resistant nickel plating. The thin, breakable, air-tight metal membrane 36 is placed inside cover 31, extending and held along all facing surfaces of the cover and to its rim 32. The air-tight, breakable membrane 36 covers rim 32 and its edge, and is covered with part 37. When the plastic, non-conducting ring 24, of nylon, for example, is pressed by the closure 23, part 37 positively establishes and maintains air-tightness and insulation between the covered rim 32, strongly pressing and enclosing the container closure 23 and the plastic, non-conducting ring 24 positioned in between.

In the central part of cover 31, the metal puncturing pin 34 with a sharp inward end, which is located directly above flexible membrane 36 below, is built in, and serves to release excess gas

when the membrane is pushed up by excessive gas pressure in the cell container. In the figure, the base 34-6 is where the puncturing pin is welded to the upper metal cover 31. All pores and spaces of the electrode assembly 13 retain electrolyte. For example, good results can be obtained by using thin breakable membrane 36 made of suitable, air-tight alkali-resistant metal, such as nickel or nickel-plated copper. For example, in the case of a cell with the dimensions of a D-type cell, a good result can be obtained by using a steel cover 31 of 0.71 mm thickness and breakable thin membrane 36 of 0.005 mm thickness.

The spiral type electrode assembly can be wrapped with non-conducting film to insulate it from the surrounding metal container. The cathode and anode 14(+) and 15(-) of the cell are connected to the exposed terminal at the cell container with flexible metal wires 17 and 16. Wire 17 making contact with cathode 14 is lead through a slit in the upper insulating plate 19 locat[illegible] on electrode assembly 13, and the other end is connected to the part of the metal cover 31 and the fixed, breakable, thin metal membrane 36 by the weld 17-1. The anode wire 18 is lead through a slit at the bottom insulating plate 19-1 and its other end is connected to the central part of bottom 22 of the metal container lying underneath by electrode weld 18-1. The electrode assembly 13 has central opening 13-1 extending in axial direction; the size of the opening has to be large enough for a long welded electrode to be inserted through the upper opening and to reach bottom 18 of the container, so that the weld 18-1 can be formed.

According to the invention, the cell container has the usually closed gas vent hole which prevents gas and vapor escaping from the broken membrane from leaking outside under normal conditions but which allows the gas or vapor to leak out when the internal gas pressure increases to more than 12.7 kg/cm^2, in order to protect the above-cited type of rechargeable cell from a gradual, continuous deterioration due to loss of electrolyte after damage of the membrane caused by excessive internal gas pressure.

An example of this invention is shown in Fig. 1. It was [illegible]

[illegible]

Under normal conditions gas vent 43 is closed with the valve part 46 which is pressed and held against rim 44 of the gas vent by the part of metal closure 47 lying above. The valve part 46 in the form shown in the figure is formed of an organic polymer which is airtight and elastically flexible and is resistant to corrosion due to the alkaline electrolyte used in this kind of cell, and consisting of the following: an elastomer, such as neoprene, butyl rubber, alkali-resistant fluorocarbon polymer, such as polyethylenetetrafluoride (TEE in short), a copolymer of polyethylenetetrafluoride and propylene hexafluoride (FPE in short), and for example, other alkali-resistant polymers listed in the Modern Plastics Encyclopedia published in 1963 and the following years in the U.S.

In another practical version, the valve part can be a spherical valve part or ball 46 made of metal or strong alkali-resistant, airtight plastic, such as a fluorocarbon polymer. The central part of the container closure 47 is partially separated from the closure by the longitudinal slits 47-1 to form a pressure supporting bar. Bar 47 on the closure is designed so that it can independently deform elastically and also so that it presses on valve part 46 with a certain pressure by which the sealing surface of rim 44 on cell cover 31 is sealed under a certain pressure. The shape and dimensions of the central part 47 of the closure which contacts the valve part 46, is designed so that the part is deformed inside, and that its elastic deformation results in a certain pressure with which the movable valve part 46 presses on the sealing surface of rim 44 surrounding the gas vent. The metal cover 47 is electrically connected to the cell cathode connector 17. The terminal connection is made by the welded metal connection 48-1 made between the extension 48 of the metal closure and the metal cover 31 under it. Extension 32 of the metal cover is connected to an end of the cell cathode connector 17 by welded joint 17-1. The surface of rim 44 of the gas vent hole may be coated with a thin film of an alkali-resistant, airtight plastic or resin. Since the plastic coat on rim 45 of the gas vent hole is deformed by the sealing pressure imposed on the ball valve 46, the rim maintains a positive pressure seal with the ball valve 46, affording air-tightness between them. A good result can be obtained

in such a way that the sealing surface of rim 44 of the gas vent hole is coated with a thin layer of airtight, alkali-resistant plastic, such as the above-cited fluorinated resin polymer. Other airtight, alkali-resistant resins, such as heat-resistant and alkali-resistant special sylene polymers, or a copolymer of vinyl chloride and vinyl acetate cited in the Modern Plastics Encyclopedia editions of 1965 and 1966, can be used for the plastic sealing coat.

Fig. 1-A shows another example of this type of gas vent valve device for the cell. Cover 31-2 has gas vent hole 43-2 bounded by rim 44-2 of the gas vent. The upper end of rim 44-2 of the gas vent has inwardly tapered surface 45-2 with which the metal valve ball 46-2 makes contact. Pressure is applied on the ball to produce a seal with the tapered part by the plate 47-6 which is similar to the pressure bar 47 shown in Fig. 1 and Fig. 2. Fig. 1-B shows another version of the valve device shown in Fig. 1-A. The upper surface of rim 45-2 is coated with a thin layer 45-3 of alkali-resistant resin, such as a fluorocarbon or another of the above-cited resins. When an excess internal pressure higher than a certain level, i.e. 12.7 kg/cm^2, is produced during charging of the cell illustrated in Figs. 1 and 2 (or Figs. 1-A or 1-B), the thin metal membrane 36 is deformed and punctured by the projection 34 on the lid. The excess gas leaks through the punctured membrane 36 to the space under metal cover 31 with gas vent hole 43. If the internal pressure is kept above the design value, i.e. for example 12.7 kg/cm^2, the gas pressure will push the gas vent valve to break the seal with rim 44 of the gas vent so that the excess gas can leak through the gas vent slits on metal closure 47. After the internal pressure returns to the normal level below the design pressure, i.e. for example, 12.7 kg/cm^2 due to the leak of excessive gas, the valve part 46 is returned by elastic rebound of the bar of metal closure 47, so that the valve is repressed to restore the seal with rim 44 of the gas vent hole and recovers the cell in normal sealing condition. With the restored sealing conditions at the gas vent, the gas generated in cell container 21 will flow freely in the space above the broken metal membrane 36 which is positioned under cover 31 and sealed gas vent 43. If the internal pressure exceeds the design pressure of 12.7 kg/cm^2 during the following charging processes, the gas will again push on valve

part 46 from the rim 44 of the gas vent to break the seal in order to release the gas of excess pressure. Valve part 46 will recover its sealed state after the internal gas pressure drops below a certain level. The principle on which this invention is based as described with reference to practical examples, implies other possible variations and applications of the invention. Hence, it is obvious that the scope of the patent is not limited to the practical examples illustrated or described here.

The cell made by this invention has the following advantages: since it has such a structure that it is sealed with a flexible metal membrane above which a metal cover with a puncturing projection and gas vent hole is placed, and the élastic valve for the gas vent hole is placed on the metal cover with the puncturing projection and such that the gas vent hole is sealed at a certain pressure, the flexible membrane produces secure sealing of the cell and bars the external valve body from contact with the internal gas, electrolyte, heat, etc., in the cell, protecting its initial, new and reliable quality; moreover, after the membrane is punctured, the cell has a new valve type of sealing system in which good valve function can be expected, electrolyte leakage is reliably prevented, and a more reliable, better seal can be maintained for a long time resulting in a longer shelf life compared to the sealed cells with only valve or membrane made by the prior art.

Patent Claim

1. Double sealed alkaline storage cell, characterized by the fact that an elastic valve for a gas vent hole is placed on the metal cover of a sealed cell which is covered with a flexible metal membrane to seal the opening of a cylindrical cell container, that the metal cover has a projection for puncturing the membrane and the gas vent hole, and the valve is pressed and contacted with the gas vent hole under a certain pressure by the elastic metal bar fixed to the metal closure.

References

Utility No. 24220-1962
Utility No. 25157-1963
Utility No. 20936-1964

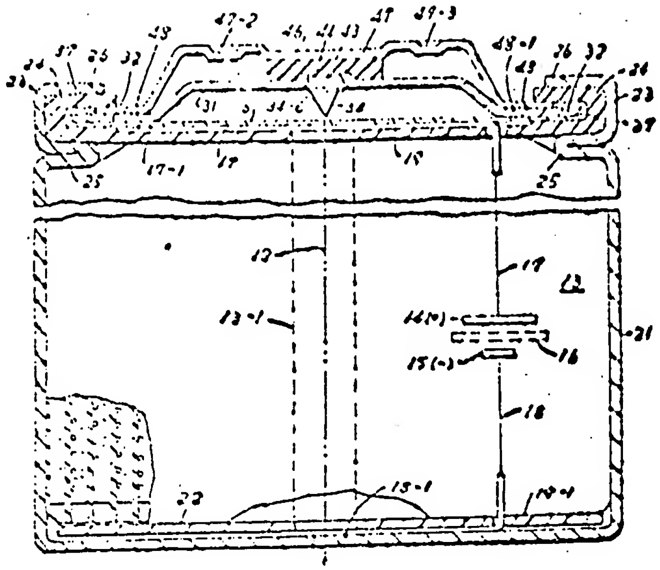

Fig. 1

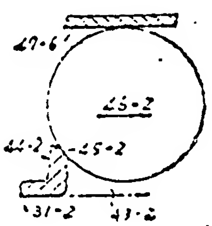

Fig. 1-A

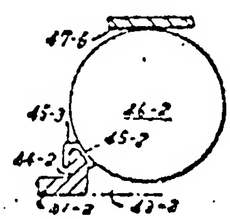

Fig. 1-B

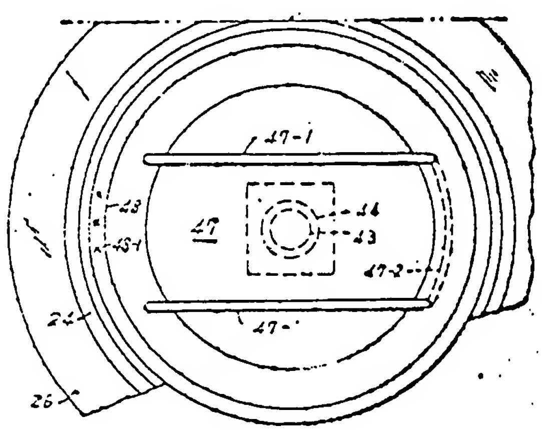

Fig. 2